

Development of the Spinal Cord :-

- It is developed from the Caudal part of the neural ~~crest~~ tube. Originally, it is composed of a layer of Columnar epithelium which proliferates.
- Later on the tube has 2 thick lateral walls + thin roof & Floor plates.

The lateral wall differentiates into 3 layers :-

- 1- Inner ependymal $\rightarrow$ Lining the central canal "Columnar ^{cells} ciliated"
- 2- Middle mantle ^{form} $\rightarrow$ The gray matter
- 3- Outer marginal $\rightarrow$ Constitute the white matter.

Sulcus limitans appears dividing the lateral wall into :-

- 1- Alar lamina (Sensory cells) $\rightarrow$ Posterior horn
- 2- Basal lamina (Motor cells) become Anterior horn

* The cavity of the spinal cord at first is oval then becomes diamond shaped

• Growth of the Spinal Cord :-

- 1- Early in development $\rightarrow$ it fills the vertebral canal
- 2- At birth $\rightarrow$ The vertebral column grows more rapidly than the spinal cord so, the lower end of spinal cord



Lies opposite 3rd Lumbar vertebra.

3- In adult $\rightarrow$ opposite the lower border of 1st or upper border of the 2nd Lumbar vertebra.

* Congenital Anomalies: 4

- (1) Spina bifida Occulta: due to failure of fusion of the dorsal part of the vertebra. So, the vertebra do not fully enclose the spinal cord.
- (2) Meningocele: The meninges bulge through the defect.
- (3) Meningo-myelocele: The meninges & spinal cord bulge through the defect.
- (4) Myelocele: the spinal cord is exposed to the surface through the defect in the vertebral column.

* Neural Crest * 3

↓ The Neural Crest } folds to form Neural tube.
is developed at the fusion of the neural folds which form the margins of the neural groove. It forms a strip on the dorsolateral aspect of the neural tube on each side.

↓ Derivatives & Fate of Neural Crests.

① Cranial nerve sensory ganglia of 5, 7, 8, 9 & 10 Cranial nerves.
② This is the Cranial part

③ The Caudal part gives rise to the primitive Spinal Ganglia which give:-

- Carotid body in the neck
- Adrenal Medulla in the Abdomen
- Sympathetic Ganglia
- Spinal Ganglia
- Parasympathetic Ganglia
- The Pia & arachnoid mater.
- Para-aortic Ganglia.

* Development of the Heart *

4

It is developed from the ^{mesoderm} ~~mesod~~ in front of the buccopharyngeal membrane. It appears as 2 heart tubes in the floor of the pericardial cavity. After folding, the tubes lie in the roof of the cavity. The 2 tubes unite to form single tube which invaginates the pericardial cavity.

The tube suspended from the pericardial cavity by dorsal mesocardium which absorbed later to form the transverse sinus of pericardium.

The single heart tube will show 5 dilations.
By constrictions in the tube

Embryonic dilation	Adult Structures
① Sinus venosus	$\nearrow$ Rt. horn $\searrow$ Lt. horn Smooth part of right atrium Coronary sinus
② Common atrium	- Rough part of right atrium (Atr. wall + Rt. auricle) - Rough part of left atrium (Lt. Auricle)
③ Common Ventricle	- Rough part of right ventricle. - Rough part of Left ventricle.
④ Bulbus Cordis	- Smooth part of right ventricle (infundibulum) - Smooth part of Left ventricle (vestibule)
⑤ Truncus arteriosus	- Ascending aorta. - Pulmonary trunk.



As a result of rapid growth of the heart it bends
to form an S-shaped loop. The Sinus Venosus receive
all veins of the Fetus. Formed of small median part
(connected to the Common atrium) + 2 horns (Right & Left)
Each horn is connected to:

- ① Vitelline
- ② Umbilical & Common Cardinal veins

* Fate of the Sinus Venosus:-

- Right horn absorbed into the right atrium
- Left horn & body are atrophy $\Rightarrow$ to give Coronary Sinus
- Left Common Cardinal vein $\Rightarrow$ oblique vein of Left atrium.
- Right Common Cardinal vein $\rightarrow$ Lower $\frac{1}{2}$ of S.V.C

Congenital anomalies of the heart

① Intratrial septal defects:

- Persistent foramen ovale
- Persistent ostium primum
- Agenesis of the interatrial septum

⑤ Anomalies of the valves:

- Stenosis or Atresia.
- Extra-cusp or reduced cusp.

② Interventricular septal defects:

- Patent interventricular foramen.
- Agenesis of the ^{IV} septum.

⑥ Anomalies of heart position:

- Dextro Cardia (lies on the Rt. side of chest)
- Ectopia Cordis (exposed in the chest)
- High position of the heart due to failure of its descent.

③ Agenesis of the truncus septum

(aorticopulmonary septum) Leads to Persistent truncus arteriosus.

⑦ Anomalies of the aorta:

- Coarctation of aorta (Constriction of the aorta).
- Right aortic arch
- Double aortic arch
- Missed coronary artery.

④ Fallot's Tetralogy consists:

- 1 - Pulmonary trunk stenosis
- 2 - over-riding of the aorta (takes blood from Rt. & Lt. Ventricle)
- 3 - Patent interventricular foramen
- 4 - Hypertrophy of Rt. Ventricle.

+ Development of the Right atrium

Right atrioventricular Canal

- Components of the Right atrium

Primitive atrium

- ① The rough part (anterior wall) is derived from Right half of Common atrium chamber + Rt. 1/2 of
- ② The Smooth part (posterior wall) is derived from Right horn of Sinus venosus + Right 1/2 of atrioventricular Canal.
- ③ ~~Costa terminalis~~
- ④ Fossa ovale is formed by Septum primum But the edges of it from septum secundum. (annulus ovalis)

- Components of the Left atrium

- ① The rough part → From Left 1/2 of Common atrium chamber
- ② The Smooth part → From a - Absorbed portions of Pulmonary veins b - Left atrioventricular Canal.

Development of interatrial septum

Septum Primum descends from the roof of the common atrium toward A-V endocardial cushion.

- It is an incomplete septum leaving a caudal foramen called ostium primum.

- The Septum primum descends to close the ostium primum, but leaving a cephalic foramen called ostium secundum.

- A new septum "Septum secundum" appears to the right of the Septum primum.

The Septum secundum is sickle shaped & descends from the roof of the right atrium to close the ostium secundum gradually.

- After Birth, the 2 septa fuse. A Fossa ovalis is formed by Septum primum and annulus ovalis by the Septum secundum.

Development of the Ventricles

① Fusion of Common ventricle & bulbus Cordis

" The bulbus Cordis becomes absorbed into Common ventricle to form Common bulbo-ventricular Chamber.

This Chamber is divided by the interventricular Septum into right & left ventricles.

② Division of the bulboventricular Chamber into 2 ventricles, This occurs by development of the interventricular Septum which formed of 2 parts (Muscular + Membranous).

A: Muscular Part - sickle shaped, arises from the apex of the heart, ascends upwards to the endocardial cushions, leaving an interventricular Foramen.

B: The Membranous Part

- Extension from proximal bulbar septum.
- Extension from A-V cushions.

The right ventricle is developed from:

1. The Rough muscular Part $\rightarrow$ The Right part of the ~~muscular~~ Common ventricle. Proximal
2. The Smooth Part (infundibulum) from the right part of the bulbus cordis. Distal

The left ventricle is developed from:

1. The rough muscular Part from the left part of the Common ventricle. Proximal
2. The smooth Part (aortic vestibule) from the bulbus cordis. Distal

Fate of aortic arches

The Firsts: Disappear

The Seconds: Disappear Except the small part form Stapedial a.

The Thirds: Form Common Carotid, E.C.A, I.C.A

The Fourths: on Right side $\Rightarrow$ Subclavian a.

on Left side $\Rightarrow$ Form part of the arch of aorta.

The Fifts: Disappear.

The Sixths: on Right side: The ventral part Form the right pulmonary a. While its dorsal part disappear.

on Left side: The ventral part Form the left pulmonary a. While its dorsal part Form the ductus arteriosus.

- The upper end of the aortic Sac is divided into Right and Left horns. The Right horn gives the innominate artery. The Sac & Left horn Form part of the arch of aorta.

There are 2 ventral aorta & 2 dorsal aorta in the embryo.

The 2 ventral aorta unite to form aortic Sac &

Here 6 aortic arches coil around the pharynx to reach the dorsal aorta. The 2 dorsal aorta lie behind the gut.

Fetal Circulation

12

Oxygenated blood is carried by the Umbilical vein from the Placenta to the Left branch of portal vein. The blood passes to the I.V.C directly through Ductus venosus. Blood of I.V.C "better oxygenated" pass into the right atrium where it is directed through the Foramen ovale to reach the left atrium and then through Mitral valve to the left ventricle. Then to ascending aorta (better oxygenated). Most is distributed through the branches of the arch of aorta to the head, Neck & upper limb. A small amount pass to descend aorta. Blood of S.V.C (Non oxygenated) pass into right atrium where it is directed through Tricuspid valve to Right ventricle then to Pulmonary trunk. But because the Lung is closed the blood go to ductus arteriosus to descending aorta → Abdomen Pelvis → Umbilical arteries (Carry deoxygenated blood). Go to the placenta to do oxygenation of the blood.

Changes in Fetal Circulation After Birth

- 1) After birth, respiration starts & Lungs become expanded and the ductus arteriosus is collapsed. Blood in Pulmonary arteries is sucked in the Lung, and returns From the Lungs to Left atrium via Pulmonary veins.
- 2- The two umbilical arteries are contracted, the left umbilical vein & ductus venosus are contracted.
- 3- The pressure in the two atria become equal & Septum and Secundum Fuse & Foramen ovale Closed.

Remnants of Fetal Circulation:

- 1- The obliterated umbilical arteries Form the Lateral umbilical ligaments
- 2- The obliterated Left umbilical vein Form the Ligamentum teres of the Liver.
- 3- The obliterated ductus venosus Form the Ligamentum venosum of the Liver
- 4- The obliterated ductus arteriosus Forms the Ligamentum arteriosum.
- 5- Septum Primum Forms the Floor of the Fossa ovalis, Septum Secundum Forms the annulus ovalis (Margin of Septum primum).

Development of the hypothalamus

The Forebrain or Prosencephalon gives 2 optic vesicles (the future eyes) then divides into 2 lateral & a median part called the diencephalon and this is the future of thalamus & hypothalamus (its cavity is the third ventricle)

↳ The brain develops from the cranial part of Neural tube which expands to form the Brain swelling. 2 constrictions appear in the brain swelling, dividing it into 3 parts called brain vesicles one of them is Forebrain. -->